Relational Databases

Introduction

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Temporary Storage

- Information is stored in cache or memory
  - e.g. an inverted index
  - e.g. loading a file into memory

- Provides fast access to information

- Disappears when the system powers off
  - This is *volatile memory* (not the volatile keyword!)

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Persistent Storage

- Information is stored on disk
  - e.g. a file saved on a hard disk or USB drive
  - Can be distributed

- Provides slower access to information

- *Non-volatile memory*
  - Contents are not lost when power is shut off

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Flat Files

- Can be thought of as several disconnected tables

- Stored via text
  - e.g. comma-separated values (csv)

- Difficult to find data
  - e.g. find all deposits over $100

- Are there issues with concurrency and consistency?

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Flat Files

Customer File

Customer ID	Company Name	Contact First Name	Contact Last Name	Job Title	City	State
6	Company F	Francisco	Pérez-Olaeta	Purchasing Manager	Milwaukee	WI
26	Company Z	Run	Liu	Accounting Assistant	Miami	FL

Employee File

Employee ID	First Name	Last Name	Title
2	Andrew	Cencini	Vice President, Sales
5	Steven	Thrope	Sales Manager
9	Anne	Hellung-Larsen	Sales Representative

Product File

Product ID	Product Code	Product Name	Category	Quantity Per Unit	List Price
5	NWTO-5	Northwind Traders Olive Oil	Oil	36 boxes	$21.35

Relational Tables

Customer Table

Customer ID	Company Name	Contact First Name	Contact Last Name	Job Title	City	State
6	Company F	Francisco	Pérez-Olaeta	Purchasing Manager	Milwaukee	WI
26	Company Z	Run	Liu	Accounting Assistant	Miami	FL

Order Table

Order ID	Customer ID	Employee ID	Order Date	Shipped Date	Shipping Fee
51	26	9	4/5/2006	4/5/2006	$60.00
56	6	2	4/3/2006	4/3/2006	$ 0.00
79	6	2	6/23/2006	6/23/2006	$ 0.00

Database Management System

- Handles the storage, maintenance, and retrieval of data

- Manages concurrent data access

- Transactions are atomic

- Often separate physical, logical, and external layers
  - i.e. how the data is stored may not be how it is viewed!

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Relational DBMS

- Support relationships between tables
  - One-to-one, one-to-many, many-to-many

- Able to join data across tables using queries

- Stable and mature, lots of providers!
  - MySQL, PostgreSQL, SQL Server, Oracle, IBM DB2, MariaDB, SQLite, …

https://docs.oracle.com/javase/tutorial/jdbc/overview/database.html

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User Authentication

```
users (
  id integer PRIMARY KEY,
  username varchar(100) NOT NULL UNIQUE KEY,
  pwd varchar(50) NOT NULL  );

user roles (

  user_id integer NOT NULL,
  role_id integer NOT NULL,
  UNIQUE KEY (user_id, role_id),
  INDEX(user_id)  );

roles (
  id integer PRIMARY_KEY,
  role varchar(100) NOT NULL UNIQUE KEY  );
```

http://www.eclipse.org/jetty/documentation/9.3.x/configuring-security-authentication.html#jdbc-login-service

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OWASP Top 10 Security Flaws

1. Injection flaws

2. Broken authentication, session management

3. Sensitive Data Exposure

4. XML external entities (XEE)

5. Broken access controls

1. Security misconfiguration

2. Cross-site scripting (XSS)

3. Insecure deserialization

4. Using components with known vulerabilities

5. Insufficient logging & monitoring

https://www.owasp.org/index.php/Category:OWASP_Top_Ten_Project

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http://xkcd.com/327/
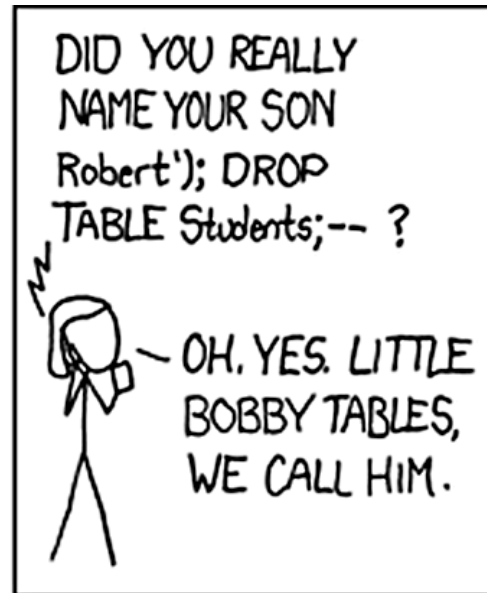
Swedish Election Hack (2010)

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Euro Traffic Camera

https://gizmodo.com/5498412/sql-injection-license-plate-hopes-to-foil-euro-traffic-cameras

Other stuff @ USFCA

- **Database design course**
  - CS 333 Intro to Database Systems

- **Non-relational (NoSQL) Databases**
  - Column/distributed (e.g. Cassandra)
  - Document databases (e.g. MongoDB)
  - Graph databases (e.g. Neo4j)
  - Key/value (e.g. Dynamo)

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